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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

This Issue

GENERAL PURPOSE GREASES

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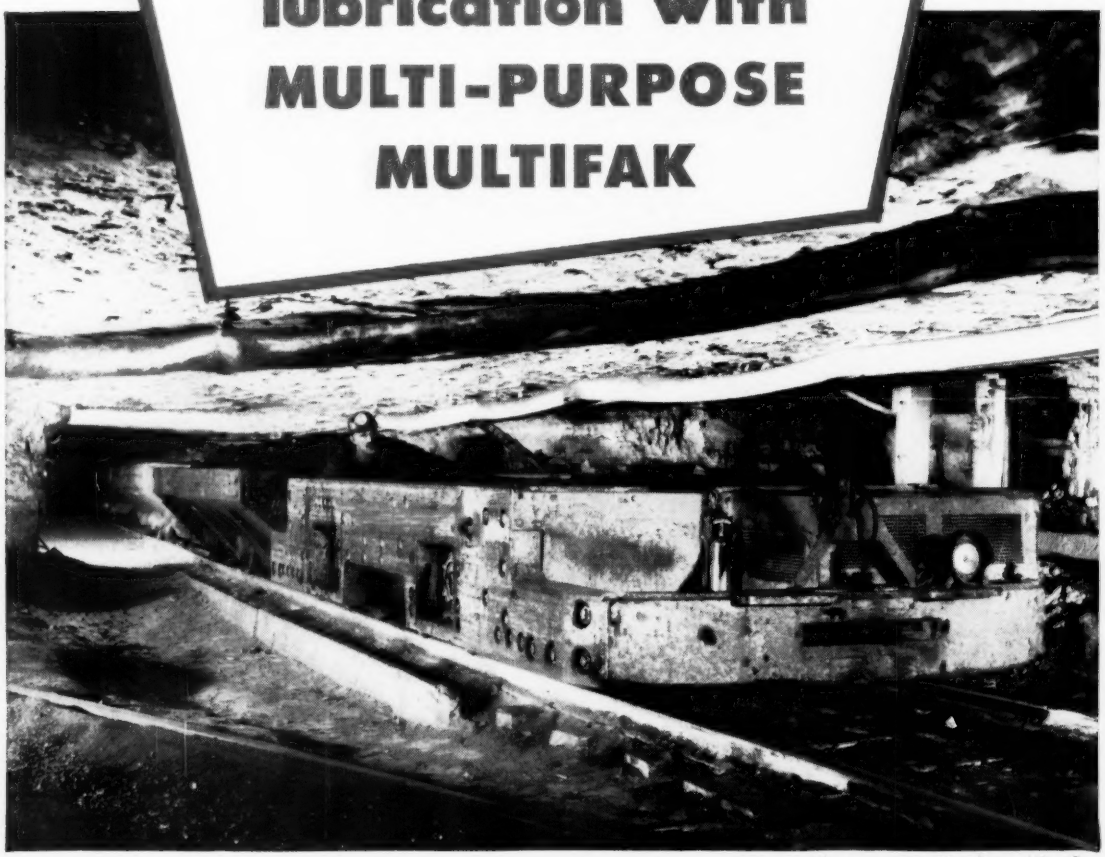

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FOR THE COAL MINING INDUSTRY

LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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GENERAL PURPOSE GREASES

Not too many years ago only a few, relatively simple greases, usually containing either calcium or sodium soap as the thickener, were manufactured and marketed in quantity and used satisfactorily for the lubrication of a rather limited number of different type applications where oil could not be used effectively. Over the years, the popularity of grease lubrication with machinery designers has increased to the extent that today this type of lubrication is specified for a wide variety of equipment operating under wide ranges of speed, temperature and other conditions.

Spurred on by the ever increasing demand for greases that would lubricate satisfactorily under the more and more stringent conditions which machinery developments imposed and by their own desire to improve the qualities of greases, the grease research chemists have made tremendous strides toward more versatile lubricants. This progress, which has been a result of research directed toward both the improvement of existing types of greases and the development of new ones, is evidenced by the relatively large number of good greases of different types available for the lubrication of today's machinery.

The most recent developments in lubricating greases include the so-called "synthetic-type", which contain synthetic oily materials in place of all or part of the usual petroleum oil component, and the so-called "non-soap" or "solid-thickened" greases which utilize finely divided solid materials such as silica and chemically treated clay in place of soap as the thickening agent.

The American Society of Testing Materials for many years defined grease as "a semi-solid combination of petroleum products and a soap or mixture of soaps, with or without fillers, suitable for certain types of lubrication." With the advent of the above developments, it became necessary to modernize the definition to the following, which now appears in the petroleum testing manual of the ASTM: "Lubricating Grease—A solid to semi-solid product of dispersion of a thickening agent in a liquid lubricant. Other ingredients imparting special properties may be included."

The availability of these new type greases, along with the improved "old type" products, makes it possible today to use grease lubrication very satisfactorily under conditions which in the not too distant past would have been considered practically impossible. At the same time, it has created a small state of confusion for the consumer because the term "all-purpose" was used for a limited time in connection with some new products, and presently the term "multi-purpose" is used extensively.

The term "all-purpose" is quite misleading because it infers that a product will satisfactorily lubricate all different kinds of applications under any and all conditions of operation. Unfortunately, however, the type of grease that can do this and

warrants this description has not been developed, although such a development is the ideal goal of every grease research chemist.

The term "multi-purpose" is a better one, but it too is somewhat misleading if it is not qualified as to the field of application, such as automotive, aviation, etc. The overall conditions of operation encountered in one field of application are rarely the same as those encountered in another field. Accordingly, a grease which has the necessary characteristics and properties that make it "multi-purpose" for a given field of application, may not be suitable for the overall conditions in a different field and an attempt to use it as "multi-purpose" indiscriminately could lead to disappointing results.

Furthermore, the term "multi-purpose" should not be interpreted as applying to a particular type of grease such as lithium, calcium, sodium, etc. There has been a strong tendency to think along this line as a result of widespread advertising of products of a particular type, but such thinking is erroneous. In the automotive field, for instance, where lithium base greases have been found to be very good multi-purpose lubricants, calcium base greases have been developed which perform equally well. This is also true with respect to different types of greases in other fields.

GENERAL CONSIDERATIONS

The suitability of a grease for either a given application or a number of different applications is not primarily a question of the type of grease but rather one of whether the characteristics of the grease are such that it will provide satisfactory lubrication under the conditions of operation. In other words, satisfactory grease lubrication for one or more applications is resolved by fitting together the characteristics of greases and the following service conditions:

a. Type of Service (plain bearing, anti-friction bearing, gears, etc.)
b. Speeds
c. Loads
d. Temperatures (both operating and environmental).
e. Method of Application (hand, gun, centralized system).
f. Frequency of Application.
g. Moisture Conditions (dry, humid, severe water washing).
h. Other Possible Contamination Conditions.

Although there are occasions when a single operating condition, such as extremely low temperature, may be the most important factor that has to be considered in selecting a grease for an application, in most instances the overall conditions of operation must be considered. This is definitely the case when it is desired to lubricate a number of different kinds of equipment with a single product, for not only do the operating conditions vary for different types of equipment, but they also can vary between different applications on a given piece of equipment.

The major difference between different type greases lies in the combination of properties rather than the specific properties exhibited by each. Although it is true that a given type of grease may possess some specific unique characteristics, in most instances a number of the properties exhibited by one type will also be exhibited by another. However, the particular combination of properties of one type is practically never the same as that of any other.

The best grease to use for one or more applications obviously is one that has the overall combination of properties which meets the requirements imposed by the conditions of operation. The variety and range of these conditions, therefore, determines whether the grease applications in a given plant or field can be handled satisfactorily by a single grease and whether the grease has to be of a particular type.

As mentioned previously, a grease which has the properties required to meet all conditions of operation has not yet been developed. All greases, however, are quite versatile and any grease, regardless of type, can be considered a multi-purpose lubricant if its particular combination of properties is suitable for the specific combination of operating conditions of all or most of the applications in a given plant or field.

Due to space limitations, it is impossible to discuss all the various types of greases and fields of application. Therefore, the subsequent discussion is concerned mainly with those types of normal soap-thickened, petroleum oil greases (i.e., greases that do not contain fillers or special additives such as those imparting EP properties) that are recommended widely for general industrial application. These are:

a. Calcium base greases (both general and high melting point)
b. Sodium base greases
c. Sodium-Calcium mixed base greases
d. Lithium base greases.

It is recognized that greases containing extreme pressure additives are used in the industrial field for multiple applications. The use of such greases, however, is more or less restricted to certain types of plants, such as steel mills. Therefore, they are considered to fall in the category of special greases.

As for the "synthetic type" greases, their cost is too high to justify their being recommended except in special fields and/or for special applications where their unique properties are required.

Figure 1 — NLGI Grade 1, Grease containing a solid thickener and synthetic oily component. Suitable for temperatures in the range of minus 40 to 400°F.

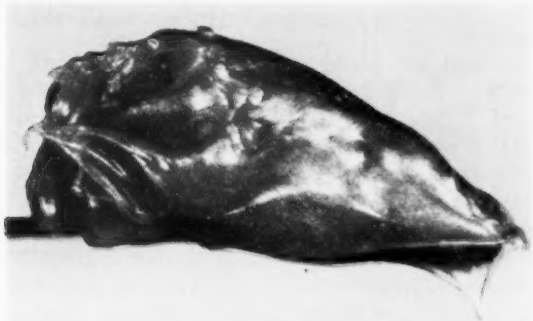

Figure 2 — NLGI Grade 2, Lithium Soap Grease containing rust inhibitor which makes it exceptionally suitable where water conditions may be a factor.

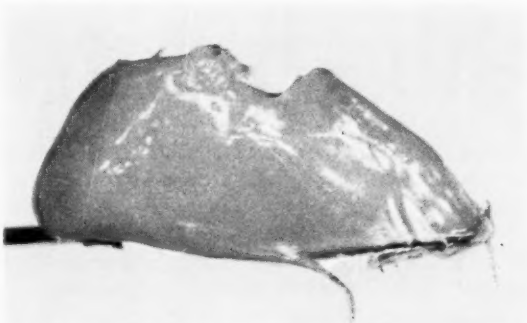

Figure 3 — NLGI Grade 2, Lithium Soap Grease suitable for use in applications up to 300°F.

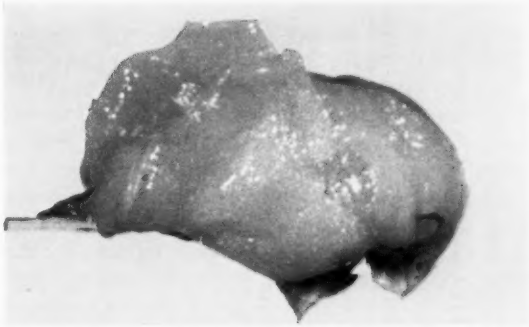

Figure 4 — NLGI Grade 2, Water Stabilized Calcium Soap Grease suitable for use at temperatures up to 175°F.

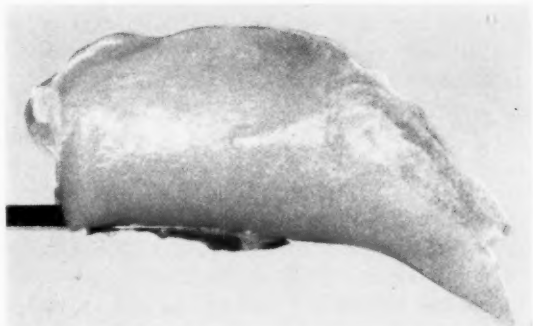

Figure 5 — NLGI Grade 2, Sodium-Calcium Soap Grease suitable for operating temperatures from minus 20 to 250°F.

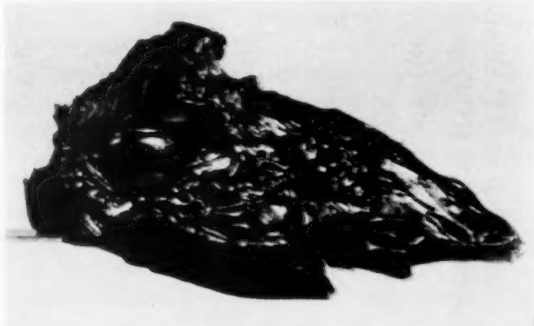

Figure 6 — NLGI Grade 2, Calcium Soap Grease meeting Military requirements for automotive and artillery grease.

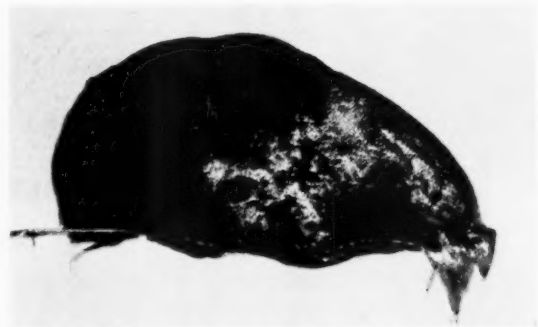

Figure 7 — NLGI Grade 2, Sodium Soap Grease which has a fibrous texture and is suitable for use at 250°F.

Figure 8 — NLGI Grade 2, Sodium Soap Grease suitable for operating temperatures up to 300°F.

TABLE I
GENERAL CHARACTERISTICS OF GREASES
COMMONLY USED FOR MULTIPLE APPLICATIONS

Type of Grease	*Calcium-General*	*Calcium-High Melting Point*	*Sodium-General*	*Sodium-Calcium*	*Lithium-General*
High Temperature Properties					
Dropping Point, °F.	200-225	280	300-450	315	360
Condition After Heating Above Melting Point and Cooling	Separate—when properly chemically stabilized have non-separating properties.	Separate	No change when worked.	No change when worked.	No change when worked.
Maximum Continuous Useable Temperature, °F.	175	225	250-300	250	250-300
Low Temperature Characteristics[1]					
Pumpability	Good to Fair	Good to Fair	Good to Poor	Good to Fair	Good to Fair
Starting Torque	Medium to Low	Medium to Low	High to Low	Medium to Low	Medium to Low
Performance in Presence of Water					
Water Absorption	Absorb limited amounts.	Absorb limited amounts.	Readily absorb water.	Absorb limited amounts.	Variable — some greases absorb large amounts.
Resistance to Water Washing	Good	Good	Generally poor; however, some sodium greases have good resistance to water washing.	Resistant Good	Resistant Good
Rust Protection	Poor—unless rust-inhibited.	Fair—unless rust-inhibited	Good to Fair	Poor—unless rust-inhibited	Poor — unless rust-inhibited.
Stability on Working	Fair to Poor	Excellent	.....Excellent to Poor — varies greatly with composition.....		
Ultra High Speed Performance	Poor	Good	Good to Fair	Excellent to Poor	Poor
Texture[1]	Buttery	Buttery	Fibrous to Smooth	Fairly Buttery to Fibrous	Buttery to Stringy
Extreme Pressure Properties	.....Poor — unless extreme pressure additive is present.....				

[1]Low temperature characteristics are affected by the texture, viscosity of the oil and other compositional components.

This also is true of some of the "solid-thickened" greases but, regardless, greases of this type are relatively new and more experience must be gained before their full scope of versatility and best fields of application are known.

The properties of greases (physical, chemical and performance) depend not only upon the type and quality of their ingredients but also upon the method used in their manufacture. As a result, differences not only exist between the characteristics of different types of greases of the same consistency grade but also can and do exist between different greases of the same type and consistency grade. One, therefore, should not get the conception that all greases of a given type will exhibit identical characteristics, or that a hard and fast general comparison can be made between the characteristics of the different types.

While some of the physical and chemical properties of greases are related to performance, in general they are not indicative of performance. Their principal significance is in the control of manufacture because they are indicative of product uniformity. Accordingly, they are of primary importance to the grease manufacturers and should be of primary importance to the consumer only in cases where it is desired to establish purchase specifications for assuring receipt of a uniform product. However, care must be exercised in writing such specifications, for if they are too restrictive in respect to physical and chemical property requirements, some products that are entirely satisfactory performancewise may easily be excluded.

The performance characteristics of greases, on the other hand, are of primary interest to both the manufacturer and the consumer. The latter must lubricate his equipment effectively in order to maintain production schedules and avoid costly shut-downs for repairs. Many cases of failure of greases to perform satisfactorily are the result of an attempt by the consumer to extend the use of a product of a particular type and thereby subject it to conditions for which it is not suited. It, therefore, is to the consumer's advantage to have some general knowledge in regard to the performance properties of various types of greases used for general purpose lubrication.

PERFORMANCE CHARACTERISTICS

As a guide in this regard, Table I, page 128, presents for such greases a general summary of those characteristics which most frequently must be considered in relation to the service conditions when selecting grease lubricants. It is hoped that this summary, along with the discussions which follow, will add to a broader general knowledge of the performance limitations of greases.

High Temperature Characteristics

The dropping point of a grease has been defined as "the temperature at which the grease passes from a semi-solid to a liquid state." It is not a measure of the service performance at elevated temperatures, but it must be considered where such temperature conditions are encountered because of the behavior of the grease when the dropping point is reached or exceeded.

As shown in Table I, some types of greases separate on being heated above their dropping points and do not reconstitute themselves on cooling. Others become liquid but regain their grease-like structure on cooling. Obviously, greases that behave in the former manner should not be exposed to temperatures equal to or above their dropping points. In the case of greases that behave in the latter manner, exceeding the dropping point does not result in complete breakdown and such greases can actually be used for a short period of time at or slightly above the dropping point, providing the bearing is sufficiently sealed to prevent loss of the liquid grease. Of course, it is not recommended that any grease be applied where it is known the temperature will exceed the dropping point.

It will be noted from Table I that the Maximum Steady Useable Temperatures of the various types of grease are considerably lower than the dropping points. This represents the temperature at which a grease can be used for rather extended periods of time under normal conditions of load and speed without excessive deterioration. Above this temperature, the rate of deterioration increases and rather frequent relubrication is required to obtain satisfactory performance.

In general, greases deteriorate in service primarily as a result of oxidation. At normal temperatures, the rate of oxidation is low and greases retain their lubricating ability for extensive periods of time. As temperatures increase, the rate of oxidation increases rapidly and greases lose their lubricating ability in shorter periods of time. The oxidation resistance of a grease, therefore, generally is related to the temperature at which a grease will perform satisfactorily without frequent relubrication. It should be mentioned that water-stabilized, calcium bases greases lose their water of stabilization due to evaporation at temperatures above 175°F. and break down. This, in their case, is the primary factor which determines the maximum steady useable temperature.

The oxidation resistance of greases depends upon the inherent oxidation stability of their basic components and upon whether they contain oxidation inhibitors which add to the inherent stability. Since greases, regardless of type, are

manufactured with different fats and oils and also may or may not contain an oxidation inhibitor, greases of a given type vary in their oxidation stability characteristics and, accordingly, in their performance at higher temperatures. Greases that contain an oxidation inhibitor, of course, are generally better in this respect than those that are not inhibited.

Low Temperature Characteristics

Low temperatures, as well as high, are encountered in industrial applications and, therefore, the low temperature characteristics of general purpose greases are important. Where it is necessary to relubricate equipment at low temperatures, the grease employed must be capable of being applied without excessive difficulty. Also, where it is necessary to start equipment at low temperatures, the resistance offered by the grease in use must not be such that starting is either impossible or extremely difficult.

The low-temperature pumpability and starting torque characteristics of greases, regardless of type, are governed primarily by the viscosity of their mineral oil components and are influenced to a lesser degree by other factors such as texture and type of fat. Since the oil components of greases may vary widely in their viscosity and viscosity-temperature characteristics, the low temperature properties of greases of a given grade and type, as reflected in Table I, can vary appreciably and may or may not be equivalent to those of greases of a different type and the same consistency grade.

Generally speaking, most of the common general purpose greases contain oils of medium viscosity and, accordingly, can be applied and used at relatively low temperatures without difficulty. None, however, are designed to meet extreme conditions and where these exist, special so-called low temperature greases must be employed.

Behavior in Presence of Water

Greases rather frequently are called upon to lubricate and protect working parts under wet conditions of operation. Such conditions may range from high humidity to severe water washing. The water absorption characteristics, resistance to water washing and rust protection properties of greases, therefore, are of importance and must be considered in the selection of a general purpose lubricant.

As reflected in Table I, the type of the grease generally determines its water absorption properties and resistance to water washing. Some variation in these properties, however, exists between greases of the same type and one cannot assume that all greases of a given type will behave in the same manner in the presence of moisture or water.

From the standpoint of rust preventive properties, none of the various types of greases, unless they contain an added rust inhibitor, can be expected to provide full protection against rusting. The sodium soap and high melting point calcium soap greases have some inherent rust preventive properties and are superior to the other type greases in this respect. It must be remembered that greases are designed primarily to be lubricants.

Figure 9 — Bentone Grease containing an extreme pressure additive. Bentone type greases have found applications in steel mills and other industrial plants where high temperatures are encountered.

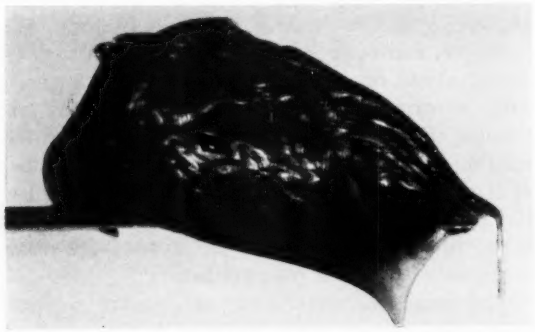

Figure 10 — NLGI Grade 2, High Melting Point Calcium Soap Grease. Greases of this type have excellent resistance against working down and are suitable for use at temperatures from minus 20 to 250°F.

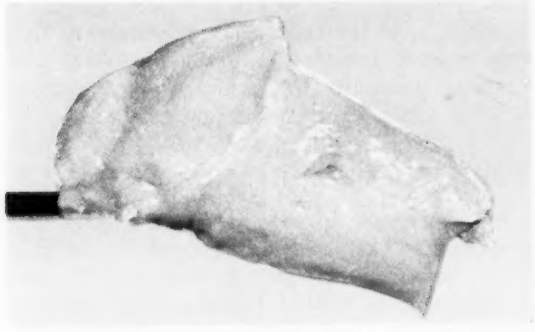

Figure 11 — NLGI Grade 2 Grease containing a synthetic oily component. Greases of this type are used extensively in aircraft applications where wide ranges in temperatures are encountered.

Figure 12 — NLGI Grade 2, Lithium Soap Grease having excellent shear resistance and suitable as multi-purpose automotive lubricant.

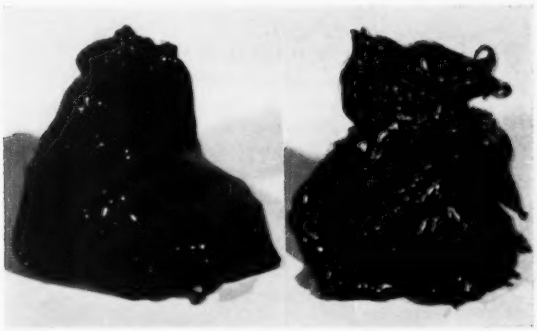

Figure 13 — Left. NLGI Grade 1, Calcium Soap Grease. Right. Same grease which has absorbed approximately 95% its own weight of water with only slight change in color and little or no change in consistency.

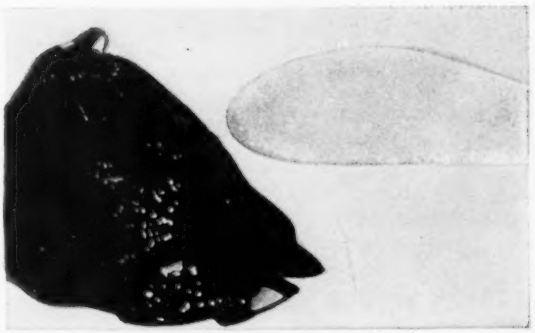

Figure 14 — Left. NLGI Grade 1, Lithium Soap Grease. Right. Same grease which has absorbed 150% its own weight of water, and on working has become a fluid emulsion.

and they cannot be expected to perform in the same manner as the various types of rust preventive compounds that are designed specifically for that purpose.

The demand for rust preventive characteristics in greases is increasing and rust inhibited greases of various types will become more readily available in the future. As is the case when building any special property into a grease, the development of a rust inhibited product is not a simple matter of adding another ingredient. The manufacturer must assure himself that the inhibitor not only serves its purpose but in no way adversely affects the other properties of the product.

Stability on Working

Except in the case of extremely soft or extremely hard greases, the consistency is normally measured by the ASTM Tentative Method of Test for Cone Penetration of Lubricating Grease (D-217-52T) and expressed as penetration at 77°F. The value obtained in this test represents the depth, in tenths of a millimeter, that a standard cone penetrates into the grease sample. If the test is made on a sample that is in the original container or has been transferred from the container with a minimum of handling, the result is designated "The Unworked Penetration." If the test is made on a sample that has been worked for 60 double strokes in the ASTM Grease Worker, as specified in the method, the result is designated "The Worked Penetration."

The "Worked Penetration," because of its better reproducibility, is used almost universally by the grease manufacturers as the method of control in the manufacture of their various consistency grades of greases for which the method is applicable. Furthermore, the consistency control ranges employed by most grease manufacturers for their various grades correspond to the ranges adopted by the National Lubricating Grease Institute for its grade classification which is shown in Table II.

The majority of the greases, regardless of type, that are employed as general purpose lubricants are N.L.G.I. No. 2 products, although in some instances a slightly softer or slightly harder grade may be employed.

The consistency of a grease as manufactured does not necessarily reflect its consistency in service. During service the grease usually is worked or sheared to a greater extent than in the ASTM Grease Worker. In general, greases tend to soften when they are worked or sheared for prolonged periods of time or at high rates. Under such conditions some greases soften very little while others show an appreciable change in consistency.

The ability of a grease to resist softening on being worked is referred to as its mechanical stability or shear resistance. It is a property which must be considered where seals are inadequate or where design is such that leakage is prone to occur. Obviously, where such conditions exist, excessive softening of the grease in service is not desirable. It should be pointed out, however, that there are applications, such as those involving oscillating motion, where a grease which softens on working is desirable because the grease will feed back more rapidly into the working area.

TABLE II
N.L.G.I. CLASSIFICATION

N.L.G.I. Number	ASTM Worked Penetration Range
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

As reflected in Table I, stability on working varies not only between types of greases but also between greases of the same type. This property is greatly dependent on the composition of the grease and the method used in its manufacture.

Ultra High Speed Performance

Where extremely high speeds are involved, oils rather than greases are the preferred lubricants; however, considerable research work is being done on the use of greases for the lubrication of bearings operating at 35,000 r.p.m. and higher. Basis available data, certain types of greases appear to be more suited for such service. Generally, however, performance depends greatly on composition of any given type of grease. How widespread the use of greases for ultra high speed operations will become and what type or types of greases will be most suitable will depend upon future studies.

SOME GENERAL MISCONCEPTIONS

As a result of the progress made in grease research and manufacture, many of the old concepts on greases are no longer entirely applicable. As a result of this and the claims made for some of the newer type greases, a considerable number of misconceptions about the different type greases exist. A few examples of such misconceptions and the fallacies of them are:

a. Calcium base greases are unsuitable for use above 200°F. because of their low dropping points and tendency to separate in service at this temperature. — *This is true of water stabilized calcium base products. There are available, however, calcium base products which are not stabilized with water. Some of these do not separate even when heated above their melting points. Others have much higher dropping points than the common water stabilized calcium greases.*

b. Calcium base greases are not suitable for the lubrication of anti-friction type bearings. — *This is generally true of the water stabilized products of this type. The higher melting point calcium base greases, however, perform satisfactorily when conditions of operation are not overly severe.*

c. Sodium soap greases are unsuitable for use where a moisture condition exists. — *This depends upon the severity of the condition. Although sodium soap greases are water susceptible and generally poorer in resistance to water washing, many of them are sufficiently resistant to permit their use where moisture contamination is a factor. Their inherent water absorption characteristics may often make their selection preferable to that of a grease of higher water resistance, where rust protection is required.*

d. Calcium and lithium base greases are not adversely affected by water contamination. — *This depends upon the composition of the grease. Certain compositions of greases of these types absorb appreciable quantities of water and lose their grease-like consistency when worked in the presence of water.*

e. Good rust protection is afforded by greases that are highly resistant to water. — *The contrary is generally true. Unless such greases contain a natural or added rust inhibitor, their rust preventive characteristics are quite poor.*

f. Greases that soften appreciably on working are inferior to those that do not. — *This depends upon the application involved. In some instances, a grease that softens on being worked is more desirable and some greases are made with this fact in mind. Where seals are inadequate or design is such that leakage is prone to occur, the use of such greases may result in undesirable leakage.*

SUMMARY

No one grease that will satisfy all conditions of operation is currently available. All the various types of greases are quite versatile but each has a certain combination of properties and certain limitations which must be recognized when grease recommendations or selections are made.

The proper grease to use for either a given application or a multiple of applications is one whose combination of properties fit the over-all conditions of operation involved. Particularly where multiple applications are involved, conditions of operation may be such that satisfactory lubrication can be accomplished with a single grease of more than one type or a single grease of a particular type. There will be many instances, however, when it will not be possible to provide satisfactory lubrication with a single grease and the use of more than one type of product will be required. In some cases, special greases may also be required to meet specific conditions.

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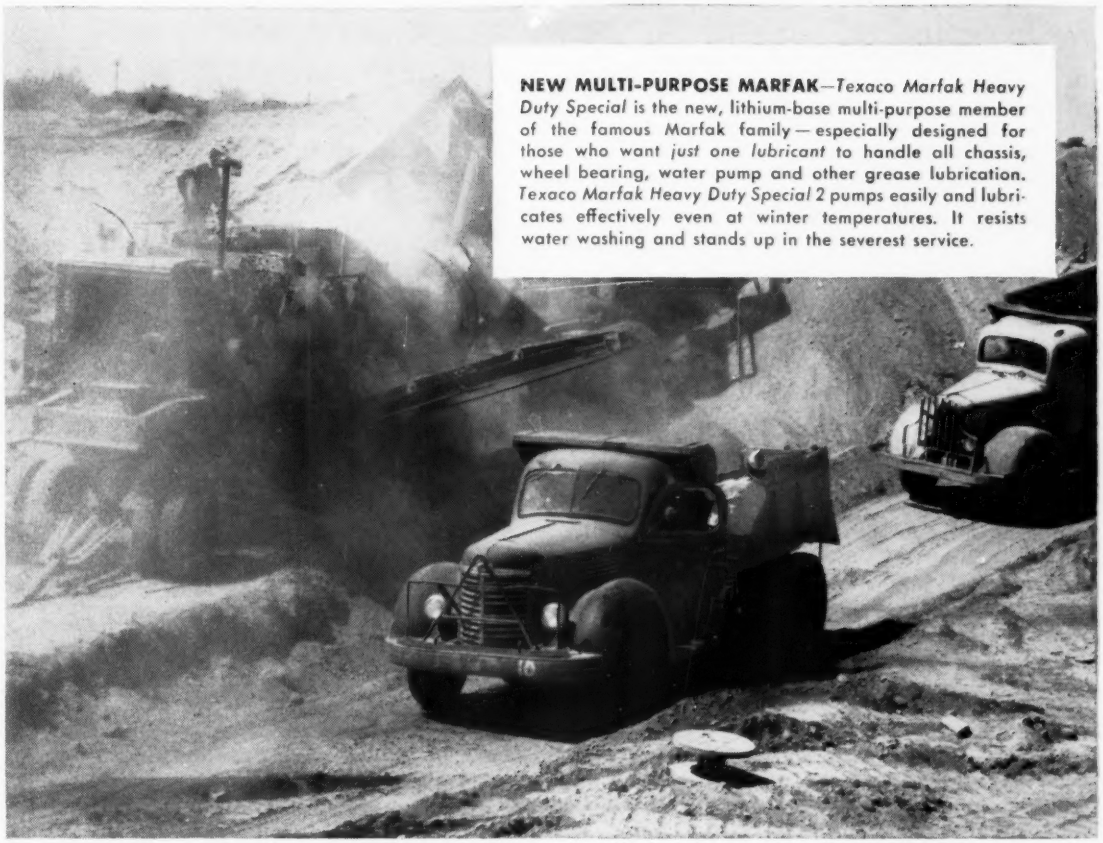

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